

IMPROVED POWER QUALITY FEATURES USING FUZZY BASED UPQC TOPOLOGY FOR BLDC DRIVE APPLICATIONS

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ABSTRACT

Implementation of the fuzzy logic controller by using voltage as feedback for significantly improving the dynamic performance of proposed UPQC module. Power quality is normally degree of any deviation from the nominal values of the voltage magnitude and frequency. Power quality problem manifested in voltage, current (or) frequency deviations. That causes power failure (or) disoperation of customer of equipment. Mostly power quality problems mitigate by UPQC. This UPQC contain combination of the the series and shunt active filters and series active filter mitigate the voltage related harmonics in power supply side and shunt active filters are mitigate the current related harmonics of non linear loads. And UPQC mitigate the harmonics and other harmonic sensitive loads. APF(active power filters),passive filters, UPFC (Unified Power Flow Converter) etc are mitigate the other power quality problems. Among from them unified power quality conditioner was widely studied by different controllers and we applied to BLDC motor for updating of load characteristics that improve the power quality in distribution side.

KEYWORDS: Series Active Power Filter, Shunt Active Power Filter, Three-Phase Four Wire Systems (3P4W), Instantaneous Active Reactive Power (P-Q) Theory

INTRODUCTION

The electric power quality mostly effected by voltage and current flickering due to arc in arc furnaces, harmonic contamination, due to non-linear loads Such as large thyristor power converters, rectifiers, and also sags and swells due to the switching of the loads etc. These above many factors effects the electric power quality. This deals mainly like issues of maintaining fixed voltage at point of common coupling (PCC) for various distribution voltage levels irrespective of voltage fluctuations, and maintaining near unit power factor drawn from electric power supply, Blocking Unbalanced Voltage and current from passive upwards from various distribution levels, voltage and current harmonics reductions in system [1]. In the distribution system from the perspective of sensitive non-linear loads, must needs power quality. In the electric power system as PQ varies due to various types of sources of generations. So in this UPQC are recommended. Hence, suitable power conditioning interfaces are suggested for sensitive load, three phase loads, and several single phase loads and non- linear loads. These type of loads primarily include production industries like paper mills, automotive plants, semi conductor, manufacturing plants, chemical and pharmaceutical industries, etc. and critical services providers like air ports, broad casting centers, medical centers, etc.

Active power filters used for power quality improvement typical grid integration problems associate with voltage and frequency compatibility and requirement of reactive and active power. [2] UPQC most widely used for comprehensive power conditioning equipment. It mitigates both voltage and current power quality problems [3]. And functionally UPQC is a combination of series active filter and shunt active filter and from incoming voltage and current the UPQC maintained desired power quality. The series active power filter is connected via transformer in series with the AC line shunt active power filter cancels current- based distortions. It compensate reactive current of the non linear nodes and as well as at the same time it improve power factor The shunt bi directional converter is connect the connected in the parallel with the load terminals.

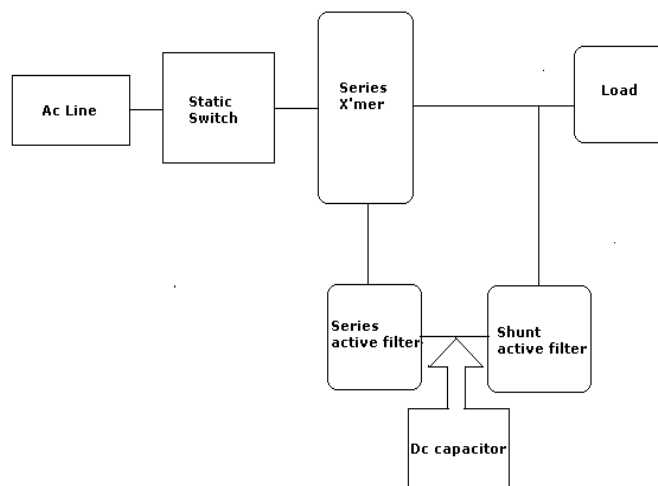


Figure 1: Block Diagram of UPQC

Thus the transformer neural part can be maintained at the virtual zero potential [4]. The unbalanced three-phase four wire distribution system can be reduced by injecting the currents using shunt active filters [4]-[6]. The configuration shown in figure 1.

UNIFIED POWER QUALITY CONDITIONER (UPQC)

UPQC is combination of 2 types of active power filters with a common self supporting DC bus. So UPQC mainly use to compensate for issues of supply voltage power quality, such as, sags, swells, voltage regulation, Unbalance flickers, harmonics, and for current power quality problems, those are harmonics, unbalance, reactive current, & neural currents. By the electric power utilities the general UPQC will be installed at various sub stations.

The main purpose of series active filter and Shunt Active Power Filter shown in the below table:

Table 1

Series Active Power Filter	Shunt Active Power Filter
In this series active filter harmonic isolation between a sub transmission system and harmonic isolation between a sub transmission distribution.	In this Shunt Active Power Filter to observe current harmonic.
In this series active filter the capacity of voltage flicker/ imbalance compensation.	In this Shunt Active Power filter compensation reactive power.
In this series active filter voltage regulation and harmonic compensation at the utility consumer of the Point Of Common Coupling (PCC).	In this Shunt Active Power filter negative- sequences current and regulate dc- link voltage in between both active filters [7].

The key components of system: as follows below are:

The UPQC used in power distribution system at substation. and UPQC simultaneously operates series & shunt compensation [8]. the UPQC contain the Lsh, Cdc LC Filter and isolation Transformer and series and shunt inverters. In UPQC(Unified Power Flow Converter has

- **Two Inverters:** In which the both series APF and shunt APF s were connected back to back with a common dc reactor as shown in figure 3.
- Lsh(shunt coupling inductor) is uses as to interface the shunt inverter to the network, it works for the smoothing the current wave Shape. isolation transformer is utilized sometimes electrically isolate the inverter from the network. Common dc link formed by using inductor (or) capacitor.
- **Cdc:** This UPQC configuration dc link formed by a capacitor and it inter connects the two series and shunt inverters. It provides constant self- supporting dc bus voltage across it.
- An LC Filters serves as a passive low –pass Filter (LPF), and It mitigate high frequency switching ripples on the output voltage of generated
- Series injection transformer used: It connect the series inverter inverter in the networks. It turns ratio is chosen suitable only then to reduction series inverter current & voltage rating.. In basic UPQC (Unified Power Quality Converter) maintain the followings are :

The basic Shunt inverter inject a current is governed by following Equation: $I_{Sh}(wt) = I_s^*(\omega t) - I_L(wt)$ (1)

Where $I_{Sh}(wt)$ = shunt inverter current $I_s^*(\omega t)$ = reference source current $I_L(wt)$ = load current respectively

The basic Series inverters inject a voltage is governed by following equation: $V_{Sr}(t) = V_{Lc}^*(\omega t) - V_s(wt)$ (2)

Where $V_{Sr}(t)$ = series inverter voltage injected voltage, $V_{Lc}^*(\omega t)$ =reference load voltage, $V_s(wt)$ = actual source voltage, respectively

In this paper developed from 3P4W VSI based UPQC using Different Load conditions using p-q theory (active and reactive power (or) three phase pq theory) control technique

3P4W DISTRIBUTION SYSTEM REALIZED WITH UPQC

3p4w distribution system available for two ways:

- From generation station one is providing a neutral conductor along with three power conductors. From figure 1 neutral conductor provided from generation station itself.
- By utilizing 3-phase delta- star transformer at distribution level.

The main advantage of 3p4w UPQC in the area of plant site is

- To restrict any entry of from load side toward utility.
- Installed to protect a sensitive load. According to plant under construction & to installation of single – phase loads, the distribution transformer upgrade from 3P3W to 3P4W system. With any involvement of major cost, utility provide the neutral conductor from transformer. This is costlier, because of it not suitable in close

vicinity[6]

In this paper current flowing towards the transformer neutral point is compensated by Four – Leg VSI Topology [8] And 4- leg VSI is get from existing UPQC(Unified Power Quality Converter) with three phase four wire (3P4W). So transformer neutral point will be at virtual zero potential.

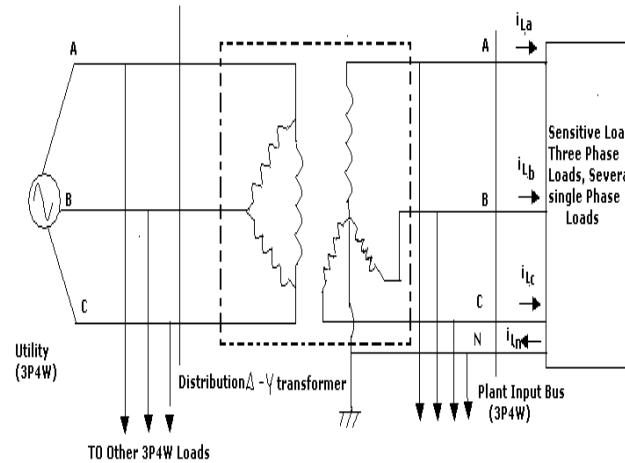


Figure 2: 3ph4w Distribution System: Neutral Provided from Δ-Y Transformer

The desired structure 3P4W system realize from 3p3w system at distribution load end. So 3P3W to 3P4W explanation of results are easier. And we introduce a new control strategy is under unbalanced load consideration conditions this generate balanced reference source currents. That results explained in detail next section [9].

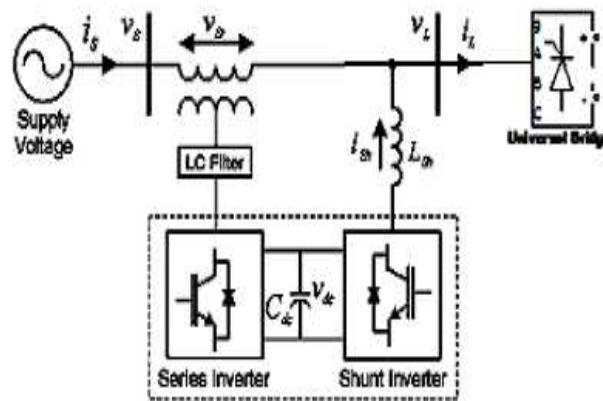


Figure 3: UPQC Structure with Nonlinear Load

FUZZY LOGIC CONTROLLER

In 1965 first paper published by on Fuzzy set theory by L A Zadeh. For some power system applications most widely use this Fuzzy set theory [10]-[12]. Fuzzy controller logically formed and since then, a new Fuzzy language improved to explain the Fuzzy properties of reality, which are sometimes difficult and even impossible to described using method of conventional. Fuzzy set rules built a group of up rules that based on the expert experience (or) knowledge data base. From the Mat lab / simulink_model of Fuzzy logic controller with the three phase four wire UPQC structure obtained the dynamic behavior of converter. In linear control technique, furthermore, Fuzzy logic control design is not possible when at same time. Dynamic performance of desirable both small & large signal by Fuzzy logic controller furthermore,

in linear control technique it is impossible. Fuzzy logic controller table shown in figure 4. It improve robustness of converter. It 's technique has been potential ability.

It consist mainly four components:

- **Fuzzification Inter Face:** It convert data suitable linguistic value
- **Knowledge Base:** It consist of a data and with the necessary control rule set and linguistic definitions.
- **A Decision- Making Logic:** In this simulating a human decision process, and also infer the fuzzy control action from definitions of linguistic variables and control rule knowledge.
- **De-Fuzzification:** It interface which yield non fuzzy control action from an inferred fuzzy control action [13]-[17]

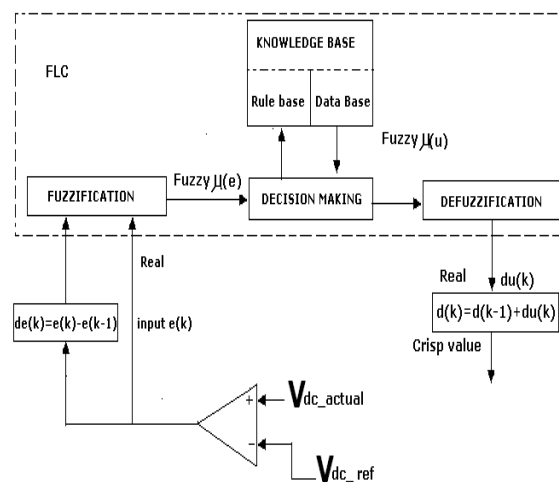


Figure 4: Block Diagram of the Fuzzy Logic Controller (FLC) for Proposed Converter

Rule Base: In the transient state only the elements of this rule base table are determined based on the theory. Large errors need coarse control, which requires coarse in-put/output variables; in the steady state, small errors need fine control, which requires fine input/output variables. Depending upon the elements of the fuzzy rule table are obtained as shown in below Table with ' V_{dc} ' and ' V_{dc-ref} ' as inputs

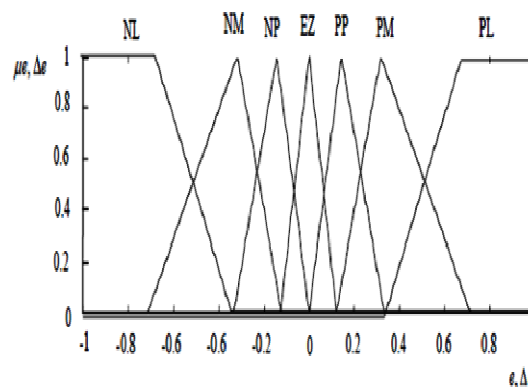


Figure 5: Membership Functions for Input, Change in Input, Output

Fuzzy controller control strategy is from linguistic into automatic strategy. And it convert these the numerical variables into linguistic variables. The table explained the following 7 fuzzy levels as: NB (negative big), NM (negative medium), NS (negative small), ZE (zero), PS (positive small), PM (positive medium), and PB (positive big) as shown in the below table.

Table 2

Δe \ e	NL	NM	NS	EZ	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	EZ
NM	NL	NL	NL	NM	NS	EZ	PS
NS	NL	NL	NM	NS	EZ	PS	PM
EZ	NL	NM	NS	EZ	PS	PM	PL
PS	NM	NS	EZ	PS	PM	PL	PL
PM	NS	EZ	PS	PM	PL	PL	PL
PL	NL	NM	NS	EZ	PS	PM	PL

MATLAB/SIMULINK RESULTS

Here the simulation is carried out in several cases, in that 1). UPQC with PI Controller, 2). UPQC with Fuzzy Controller, 3) UPQC with Fuzzy Controller with BLDC Drive.

Case 1: UPQC with PI Controller

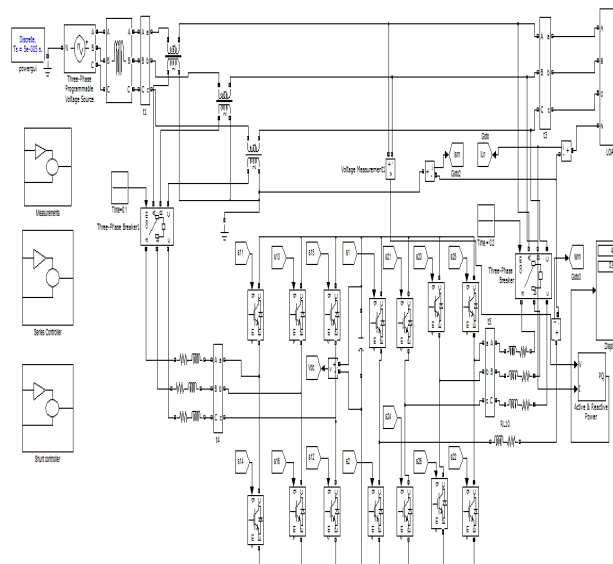


Figure 6: Mat Lab/Simulink Model of 3P4W UPQC with PI Controller

Figure 6 shows the Mat lab/Simulink Model of Proposed UPQC Methodology with PI Controller using mat lab/Simulink environment

Test-I : This Figure 7 shows the Source Voltage, Load Voltage, Compensation Voltage of UPQC with PI Controller

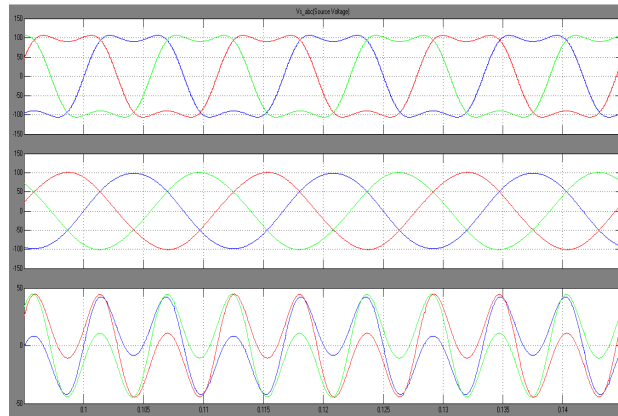


Figure 7: Source Voltage, Load Voltage, Compensation Voltage

Test-II: This figure 8 shows the Source Current, Load Current, Compensation Current of UPQC with PI Controller

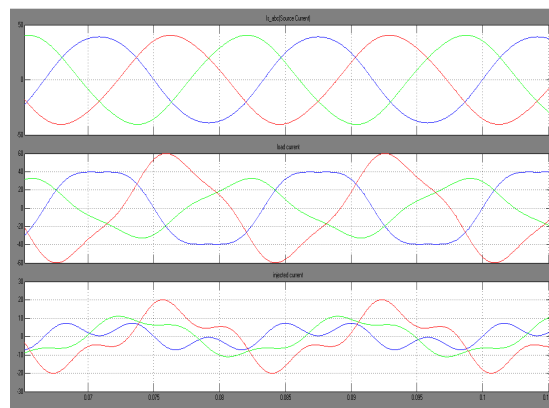


Figure 8: Source Current, Load Current, Compensation Current

Test III: This figure 9 shows the DC Link Voltage & Source Neutral Current of UPQC with PI Controller

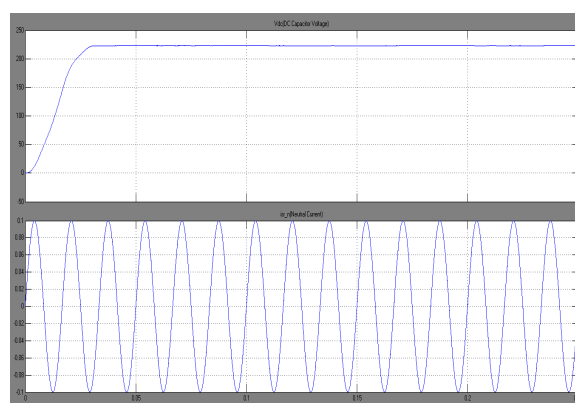


Figure 9: DC Link Voltage & Source Neutral Current

Test-IV: This figure 10 shows the Load Neutral Current & Compensator Neutral Current of UPQC with PI Controller

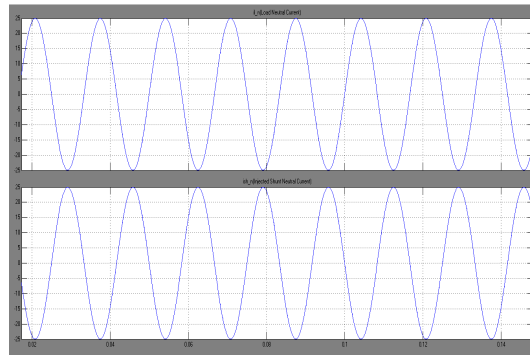


Figure 10: Load Neutral Current & Compensator Neutral Current

Test V: The figure 11 is shows the FFT Analysis of Source Current of UPQC with PI Controller, attain 2.30%

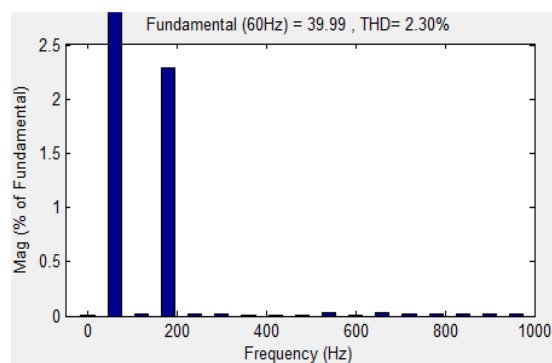


Figure 11: FFT Analysis of Source Current

Case 2: UPQC with Fuzzy Controller

Test-I: This figure 12. Shows Source Voltage, Load Voltage, and Compensation Voltage of UPQC with Fuzzy Controller

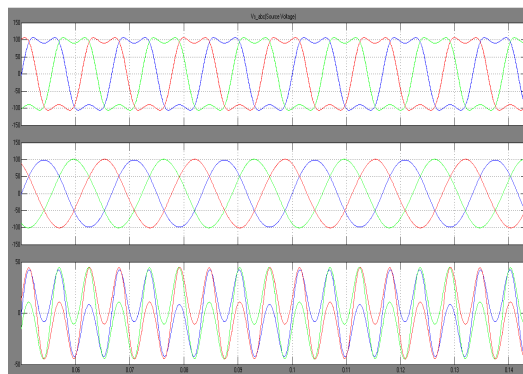


Figure 12: Source Voltage, Load Voltage, Compensation Voltage

Test-II: This figure.12 shows the Source Current, Load Current, and Compensation Current of UPQC with Fuzzy Controller

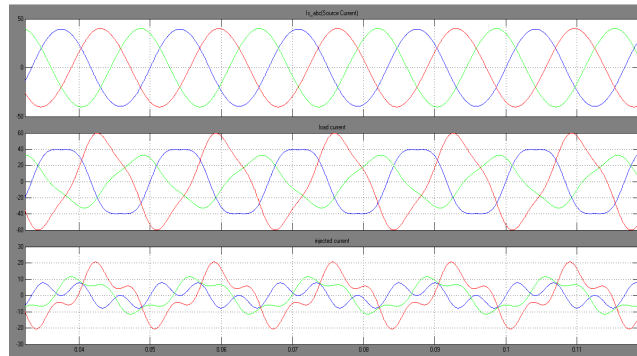


Figure 13: Source Current, Load Current, Compensation Current

Test-III: This. Figure 14 shows the DC Link Voltage & Source Neutral Current of UPQC with Fuzzy Controller

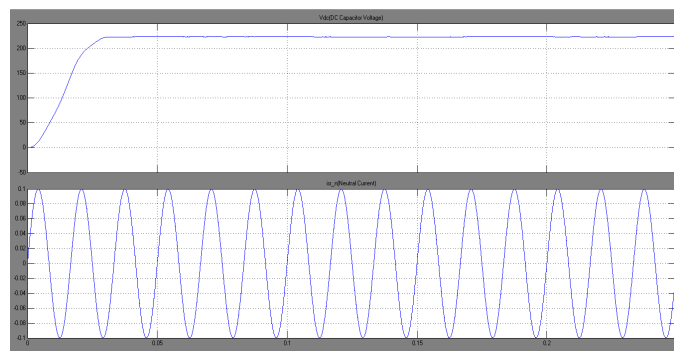


Figure 14: DC Link Voltage & Source Neutral Current

Test-IV: This figure 15 shows the Load Neutral Current & Compensator Neutral Current of UPQC with Fuzzy Controller.

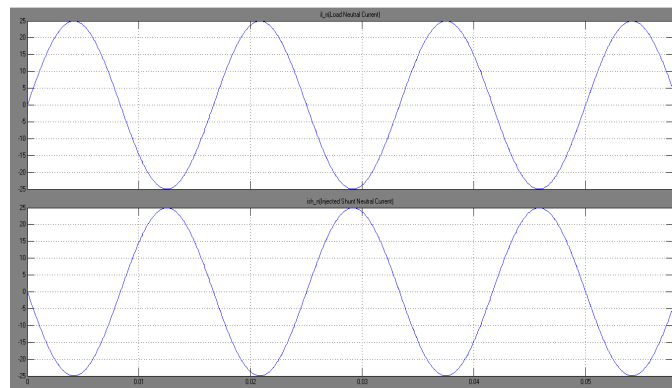


Figure 15: Load Neutral Current & Compensator Neutral Current

Test-V: This figure 16 shows the FFT Analysis of Source Current of UPQC with PI Controller, attain 1.00% as shown in figure 16. With the help of fuzzy controller attain low THD compared to PI controller and get fast response with low steady state error values, that's why used in many industrial applications.

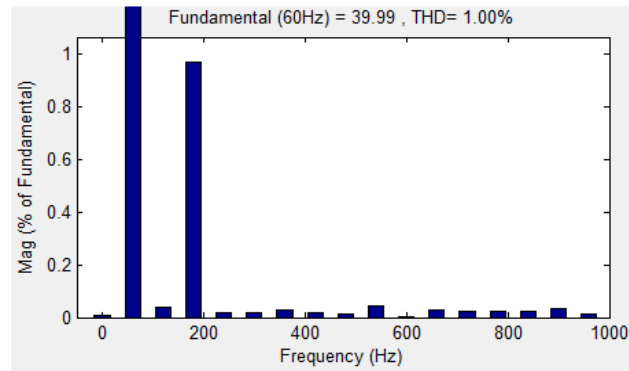


Figure 16: FFT Analysis of Source Current

Table 3

PI Controller	Fuzzy Controller
THD=2.30%	THD=1.00%

In This above table has presented a novel control of an existing UPQC within the source side. In the shunt controller (i) with PI controller & (ii) Fuzzy logic controller to improve the quality of power at PCC for a 3-phase 4-wire UPQC system. By using PI controller we get THD value is 2.30%, but using the Fuzzy logic controller THD value is 1.00%. and. The simulation results show that the performance of converter system has been found to be satisfactory for improving the power quality at the consumer premises.

Case 3: UPQC with Fuzzy Controller with BLDC Drive

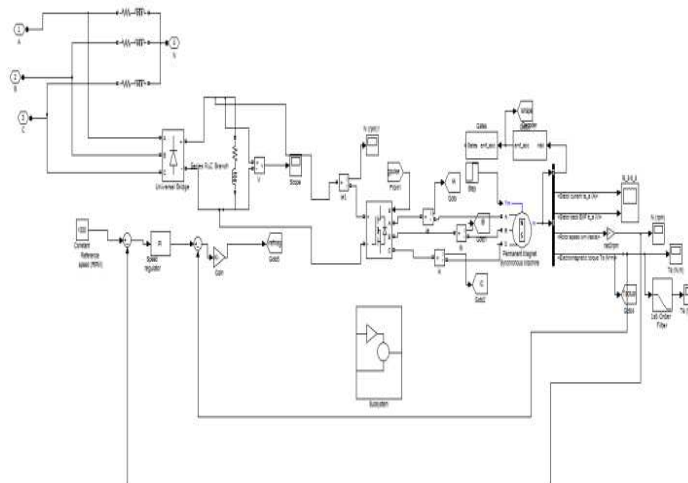


Figure 17: Matlab/Simulink Model of Proposed UPQC Methodology with Fuzzy Controller with BLDC Drive

Figure 17 shows the Matlab/Simulink Model of Proposed UPQC Methodology with Fuzzy Controller with BLDC Drive using Matlab/Simulink platform

Test –I: This figure 18 shows the Stator Current & Back EMF of UPQC with Fuzzy Controller with BLDC Drive

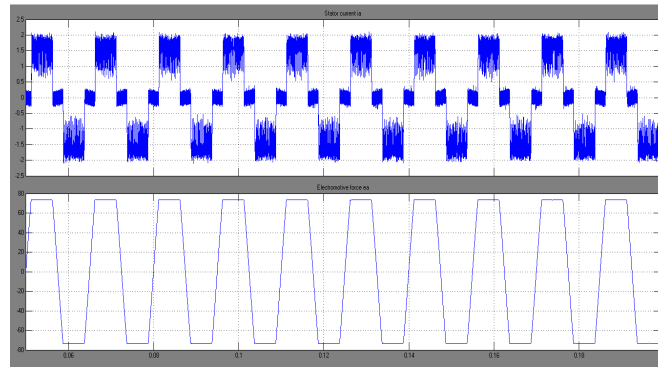


Figure 18: Stator Current & Back EMF

Test- II: This Figure figure 19 shows the Stator Current & Back EMF of UPQC with Fuzzy Controller with BLDC Drive.

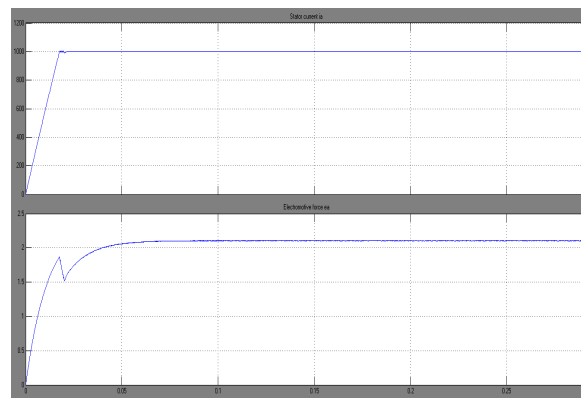


Figure 19: Speed & Electromagnetic Torque

Figure 19: shows the Speed & Electromagnetic Torque of Proposed UPQC Methodology with Fuzzy Controller with BLDC Drive. And BLDC motor Low Power Applications (Consumer electronics, Medical field etc.) and High Power Applications (Industrial Machines Vehicles, aero planes) and For Compressor (air conditioner, refrigerator) and For Appliances (refrigerator, vaccum cleaner, food processor) and For Automotive (fuel & water pumps, cooling fan, climate control).

CONCLUSIONS

The BLDC (Brush Less Dc Motor) motors are have numerous advantages over brushed dc motor & in dc motor brush performance also limits the transient response & one of the electrical drives that rapidly gaining popularity, due to their high frequency, low maintenance, it obsence mechanical commutators which allow high speed, good dynamic response and also widely used in motor applications developing high torque with good speed response, reduce audible noise & electromagnetic torque. BLDC is easier to dissipate heat because BLDC source of heating is stator while dc motor is rotor. In this paper presented design of a simulation model of 3- PHASE 4 WIRE UPQC with fuzzy controlled BLDC drive. Simulation model results shows, from the utility side the distorted and unbalanced load currents free from distortion & are act as perfectly balanced source currents. and such modeling is very useful to studying drive system. & predict the behavior of the actual system. The THD analysis is also done as per IEEE standards & from simulations observed that there will be reduction in THD (UPQC with PI controller THD=2.30% & UPQC with fuzzy controller THD=1.00%)and

improve the power quality under sag and swell conditions and also for linear unbalanced conditions. By using advanced control strategy neural current eradication is possible in this paper. Results are used to determine the range of parameters of controller while designing the system. This paper demonstrated for compensation of reactive power, voltage sag & swell, neutral currents (FOR 3-PHASE 4 WIRE SYSTEM), unbalanced for voltage and currents (FOR 3-PHASE SYSTEM), and elimination of current harmonics and voltage regulation & correction of power factor. Rotor movement regulated by speed controller & by varying frequency of the pulse based on feedback from the hall sensors. The application of this thesis is on the basis of simulation results carried out. Can be to select the proper motor specifications. To match the load requirements.

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